SOUND PRODUCTION AS COLONY DEFENCE IN *Apis cerana* FABR.

N. Koeniger and S. Fuchs, Institut für Bienenkunde (Polytechnische Gesellschaft) der Universität Frankfurt a.M., 637 Oberursel/Ts., Im Rotkopf 5 and Zoologisches Institut der technischen Hochschule Darmstadt, 61 Darmstadt, Schnittspanstr. 3

INTRODUCTION Bees in the field flee when attacked. Disturbance at or in the colony elicits defensive behaviour in which many workers take part. Defensive behaviour different from *A. mellifica* is described for all three Asiatic species of the genus *Apis* (Butler, 1954; Lindauer, 1956; Sakagami, 1960; Kloft, 1972 *et al.*), but the descriptions are often contradictory.

MATERIAL AND METHODS We have kept *A. cerana* at the Institut fur Bienenkunde in Oberursel for several years and for this work we used bees originating from the North West Province, West Pakistan. As far as it could be seen, there were no differences between *A. cerana* from Ceylon, India (Poona) and China (Peking). The bees were kept in an observation hive in a constant temperature room (32^{o}C) under constant yellow light (Radium NON INSECTA). They were allowed to fly through a tunnel and forage outside.

RESULTS

1. DESCRIPTION OF THE BEHAVIOUR A short knock on the beehive induces a short hissing sound (700 Hz) which lasts 0.5 sec (Koeniger and Fuchs, 1972). The bees show the following behaviour: the wings close quickly over the body and the abdomen jerks upwards. After this reaction the animals orientate in a negative geotactic direction and remain quiet for about 3 sec. We call this "hissing behaviour".

2. INDUCTION OF HISSING BEHAVIOUR During the first days after the bees arrived in Oberursel we noticed that hissing behaviour was easily induced by knocking on or shaking the beehives. We began analysing the release of hissing behaviour by comb vibration (Fig. 1).

With frequences over 300 Hz, it was not possible to induce hissing behaviour, but a "stop reaction" (Little, 1962: *A. mellifica*) was observed.

Airborne sound can also induce the behaviour, if the frequency is under 200 Hz (more than 85 dB). For the analysis of the airborne sounds we performed experiments under the following conditions: the combs and all wooden parts were removed and the bees were forced to settle on a cement block (45 x 45 x 15 cm). It was not possible to induce hissing behaviour with airborne sounds using this arrangement even with very high intensities (120 dB). In contrast, it was easy to induce the behaviour on the cement block by blowing at the bees. Thus airborne sounds induce substrate vibrations which in turn release the hissing behaviour.

An effective stimulus was air movement: even gentle blowing on the bees resulted in hissing behaviour. We noticed no difference in effectiveness between the warm air of breath and cold dry air which was pumped out of a bottle. Chemical stimuli such as smoke, isopentylacetate and carbolic acid were applied without success. Also tests with optical stimuli (light flashes, moving black plates, a flying hornet (*Vespa crabro*),

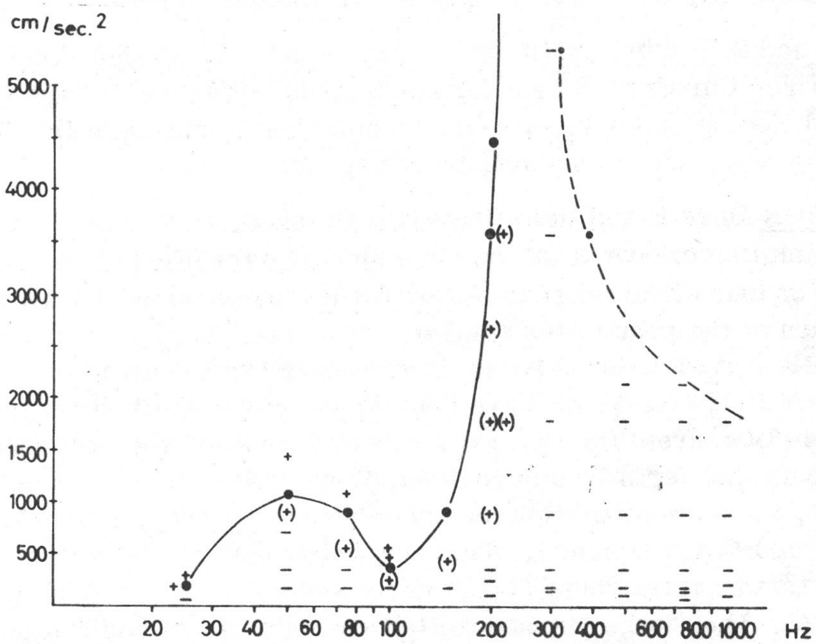

Figure 1 Reaction of Apis cerana to substrate vibrations.

+	transmitted hissing behaviour
–	no reaction
(+)	local reaction (no transmission)
---	above capacity of instrument
. . .	threshold of transmitted hissing behaviour

butterflies and mellifica bees) did not induce hissing behaviour.

3. COMMUNICATION Blowing air through a thin tube releases a hissing reaction only from bees in the path of the air current. The behaviour of these bees releases the hissing reaction of neighbouring bees. Thus hissing behaviour is transmitted from one bee to the next throughout the whole colony. Microphones installed at different places on the comb enabled us to measure transmission speed (25 cm/sec). Without combs, transmission of the behaviour is also possible. We saw several times that the behaviour was transmitted from one comb to another 8 cm away if they were bridged by a cluster of bees.

The question of whether body contact from bee to bee is necessary was tested under the following conditions. We separated a group of 700 bees on the comb by wooden partitions. We induced hissing behaviour by blowing through a tube on both sides of the partitions. No transmission occurred through the partitions. We then replaced the wooden partitions by gauze screens and the transmission of the hissing behaviour from the inside group to the outside was observed in 15 out of 25 stimulations. The distance between the two groups was about 1 cm in every case.

4. THE EFFECT OF THE HISSING BEHAVIOUR ON THE AGGRESSIVENESS We believe the transmission of the hissing behaviour to be a communication mechanism. Thus we started some experiments to show the influence on the aggressiveness of the individual bee. A black ball (diameter 10.5 cm) was swung in front of the comb at a distance of 25 cm. The number of the attack flights on this ball was used as a measurement

Programme:

Control	A. 1 min. of swinging	15 sec. pause	B. 1 min. of swinging
Test	A. 1 min. of swinging	15 sec. pause Hissing during pause	B. 1 min. of swinging

Experiment No.	Control A.	Control B.	*	Test A.	Test B.
1	7	3		6	1
2	8	4		8	3
3	2	1		4	0
4	2	2		3	0
5	4	1		4	0
6	2	1		0	0
7	11	13		7	0
8	3	1		3	0
9	10	8		10	2
10	3	4		5	2
11	7	10		3	1
Total	59	48		53	9

Table 1: Number of attack flights on a swinging black ball.
*(15 minutes interval between control and test)

for the aggressiveness. The test was carried out in the following way. The number of attacks during the first minute was recorded and then we stopped the ball for 15 sec and counted the bees attacking it in the next minute. During the 15 sec break we induced hissing behaviour by stimulation with air on the reverse side of the comb. We thus avoided stimulating the bees which were being tested on the front of the comb. The results (Table 1) demonstrate that the hissing behaviour reduced aggressiveness considerably.

5. THE EFFECT OF HISSING SOUNDS ON BEARS Bears were trained to look under a wooden box for a honeycomb. In the test, there was a loudspeaker beneath the comb which produced the hissing sound of *Apis cerana* as soon as the bear touched the wooden box. Because of the high sound level in the Zoo (around 75-80 dB) we used hissing sounds with double this intensity. We tested two Malayan bears (*Helarctos malayanos*). The first one had lived more than ten years in the Zoo, and was very apathetic. He showed no reaction to the sounds. The second one had lived only two years in the Zoo and learned the experimental situation after one trial.

After the first hissing sound the bear sprang back from the box and ran restlessly around for two minutes. The reaction of the bear to the hissing was stronger when it touched the box a second time. He growled three times and scratched at the exit door of the room. He stood up on his hind legs and crossed his front legs over his thorax and performed stereotyped shaking movements. Then a period of restless running followed and after five minutes he touched the box very carefully with his tongue. The hissing sound drove the bear back and the next restless phase began with cleaning behaviour. Seven minutes later the bear lay down in front of the exit door and remained still. After another fifteen minutes the bear approached the box very carefully and when we did not give a hissing sound turned the box over and ate the honeycomb.

Experiments with the American Kodiak bear (Ursus arctos middendorffi) showed no result. The animal did not react to the hissing sound and ate the honeycomb immediately.

DISCUSSION Defensive behaviour of Apis cerana was described as follows by Butler (1954 p. 14-15): "When a hornet and wax moth or other intruder approaches the nest, the bees shake their bodies violently from side to side in concert, a behaviour pattern which I called the shimmering behaviour. The peculiar hissing sound accompanies the shimmering behaviour of Apis indica (syn. cerana)."

Sakagami (1960 p. 174) refers to Butler but describes the shimmering behaviour quite differently: "When disturbed, c colonies respond with a peculiar communal hissing. This reaction, "shimmering" (Butler 1954), is evoked by various mechanical shocks such as a sudden blow upon the hive, the abrupt opening of the hive lid etc., but occasionally occurs without any apparent external causes. Light does not release the reaction Simultaneously with the sound production, the bees shrug their wings and push the body forward, without locomotion, by means of the legs.

The hissing behaviour is not released by hornets and butterflies and also the description of Butler indicates that the shimmering behaviour and hissing behaviour we describe are different. Nevertheless the description of Sakagami and what he understands under "shimmering" seems to be identical with the behaviour called hissing behaviour in this paper.

Sakagami described at least two other distinct defence behaviour patterns in Apis cerana on which we are now working.

For the release of hissing behaviour frequencies around 80 Hz were most effective. Frequencies around 2 kHz, which is within the range of sensivity of the subgenual organs of Apis mellifica (Autrum und Schneider 1948) do not induce hissing. Frequencies over 200 Hz release regularly the "stop-reaction" described for Apis mellifica (Little 1962).

Airborne sounds released hissing behaviour only by inducing vibration of the substrate, as the experiments with the colony on a cement block demonstrated. The transmission of hissing was shown by local stimulation with air. Transmission is possible without substrate and body contact between the bees; probably the air movement which occurs during the hissing, is the only necessary factor.

Experiments with a black swinging ball showed that hissing behaviour reduces the aggressiveness of the colony. The test with Asiatic bears indicates that the defence effect of this behaviour is due to the hissing sound. It may be possible that this is mimicry, because in most of the habitats of A. cerana snakes are quite common. Also hissing sounds are described in the defensive behaviour of many animals. Up to now there are few experiments concerning the effect of these sounds.

SUMMARY

1. Mechanical stimulation of the Apis cerana bee hive releases behaviour which is characterized by a short hissing sound (700 Hz).

2. This hissing behaviour could not be released by various chemical and optical stimuli.

3. Hissing behaviour seems to be transmitted from one bee to the other by air movement. The transmission speed is 25 cm/sec.

4. The aggressiveness of the bees is reduced after hissing behaviour.

5. Tests with Asiatic bears indicate that the hissing sound of the bee colony may be an effective defence against larger predators.

REFERENCES

AUTRUM, H. und SCHNEIDER, W. (1948) Vergleichende Untersuchungen über den Erschütterungssinn der Insekten. Z. vergl. Physiol. 31, 77-88

BUTLER, C.G. (1954) The World of the Honeybee. London.

KOENIGER, N. und FUCHS, S. (1972) Kommunikative Schallerzeugung von Apis cerana FABR. im Bienenvolk. Naturwissenschaften 59, (4), 169

KLOFT, W. und SCHNEIDER, P. (1969) Gruppenverteidigungsverhalten bei wildlebenden Bienen (Apis cerana FABR.) in Afghanistan. Naturwissenschaften 56, 219

LINDAUER, M. (1956) Über die Verstandigung bei indischen Bienen. Z. vergl. Physiol. 38, 521-577

LITTLE, H.F. (1962) Reactions of the honeybee to artificial sounds and vibrations of known frequencies. Ann. ent. Soc. Am. 55, 82-89

SAKAGAMI, Sh.F. (1960) Preliminary report on the specific difference of behaviour and other ecological characters between European and Japanese honeybees. Acta Hymenopterologica 1 (2); 171-198